

Hydrologic budget of the ORW mitigation wetland, 2002

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Introduction

Understanding the hydrologic processes of mitigation wetlands is a fundamental key in effective ecosystem restoration and creation (Mitsch and Gosselink, 2000). One indicator of success for constructed wetlands is the fulfillment of the hydrology criterion (National Research Council, 1995). Hydrologic budgets, therefore, provide valuable information to meet restoration and creation goals.

The 3-ha mitigation wetland (the billabong) at the Olentangy River Wetland Research Park, constructed in the summer of 1996, is a freshwater, oxbow wetland that receives water from the Olentangy River. When the river level is higher than the wetland, water passively flows into the wetland through a check valve and eventually returns to the Olentangy River through a control weir. Previous hydrologic budgets from the beginning were presented in Wang et al. (1997), Johnson et al. (1998), Zhang and Mitsch (2000, 2001, 2002). This paper presents monitoring hydrologic budgets for 2002.

Methods

Location of the inflow and outflow of the billabong is shown in Figure 1. A twice-daily reading (staff gauges) was used to measure the surface water level of the Olentangy River and mitigation wetland. The following equation (Mitsch and Gosselink, 2000) was used to determine hydrologic budgets for the mitigation wetland:

$$\Delta V/\Delta t = Q_{in} + Q_{out} + G_{in/out} + P_{reci} - ET \quad (1)$$

where

$\Delta V/\Delta t$ = Change of water volume in wetland over time,

Q_{in} = Inflow,

Q_{out} = Surface outflow,

$G_{in/out}$ = Ground water exchange,

P_{reci} = Precipitation,

ET = Evapotranspiration.

All parameters (water inflows, outflows, water volume, precipitation and evapotranspiration, and groundwater) in equation (1) were calculated by the following equations (Wang et al., 1997):

Inflow

$$S_i = 1.8447ah^{1/2} \quad (2)$$

$$a = 0.7372D + 1.387D^2 - 0.39993D^3 \quad (3)$$

= cross sectional area, ft

$$L_r = 723 + L_s \quad (4)$$

where

D = water depth in pipe at weir box (ft)

= min (d , max (0 , $L_r - 723.5$))

h = head causing flow (ft)

= max (0 , min ($L_r - L_m$, $L_r - 0.6D - 723.5$))

L_r = river water level (ft above MSL)

L_s = staff gauge reading, ft

L_m = mitigation wetland water level (ft above MSL)

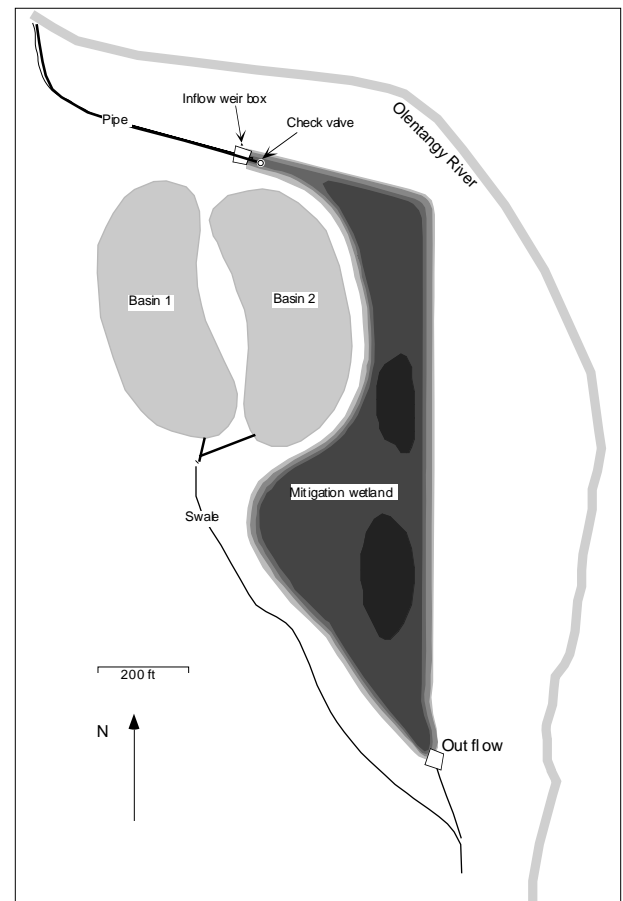


Figure 1. Location of the mitigation wetland at ORWRP.

Outflow

$$S_0 = 10.16h_0^{1.436} \quad (5)$$

where

$$h_0 = \begin{cases} L_m - 724.2 & (L_m > 724.2) \\ 0 & (L_m < 724.2) \end{cases}$$

Surface water volume

Surface water volume was based on relationships between surface area, volume, and elevation. A detailed modeling approach was given by Wang et al. (1997). The following equation was used to calculate water volume (V , ft^3) of the mitigation wetland:

$$V = \begin{cases} 3.5873 \times 10^4 L_m - 2.5938 \times 10^7 & (0 < L_m < 723.5) \\ 6.8425 \times 10^9 - 1.9121 \times 10^7 L_m + 1.336 \times 10^4 L_m^2 & (723.5 < L_m < 727.0) \end{cases} \quad (6)$$

Daily precipitation and ET

Daily precipitation and evapotranspiration data were extracted from Ohio State University and the weather station (Mitsch et al., 1995) at ORWRP. Evapotranspiration data was used from the year 1999, because of absent data from both weather stations in 2002.

Groundwater exchange

The difficulties of evaluating groundwater seepage for the mitigation wetland were presented in Wang et al. (1997). The residuals, however, were used to estimate groundwater indirectly after balancing all other components of the hydrologic budgets (eqn. 1).

Results and Discussion

Figure 2 shows the hydroperiod of the wetland and the Olentangy River for 2002. General water level trends of the billabong follow a pattern of high water levels in the early growing season, followed by drier conditions in late summer. This early flooding followed by summer drawdowns is typical of midwest marshes (Mitsch, 1992). There appear to be 4 independent flood events between January and June 2002 into the wetland. These flood events provide nutrients and introduce seeds and small organisms from across a watershed.

Figure 3 presents the relationships between surface water level (ft above MSL) and wet area (%) of the total mitigation wetland area, and wet periods (days) during two growing seasons (a: from April 20 to Oct. 20; and b: from May 1 to Oct. 31 during the period 2002). A summary of the wet days and wet area for the two growing seasons is given in Table 1. The wet periods are considerably longer than the hydrologic critical days which were given by National Research Council (1995) for wetland delineations and indicate that the design of this wetland was successful in establishing appropriate hydrologic conditions for a Midwest oxbow wetland.

Table 2 shows the annual hydrologic budgets for 2002. Daily values are given in Appendix A. By comparison, total inflow 7.0 m/yr from the river in 2002 was higher than the total inflow 6.8 m/yr from the river in 2001 but was lower than the inflows of 11.10 m/yr in 2000 and 9.25 m/yr in 1999 (Zhang and Mitsch, 2000, 2001, 2002).

References

Johnson, S.A., W.J. Mitsch and N. Wang. 1998.

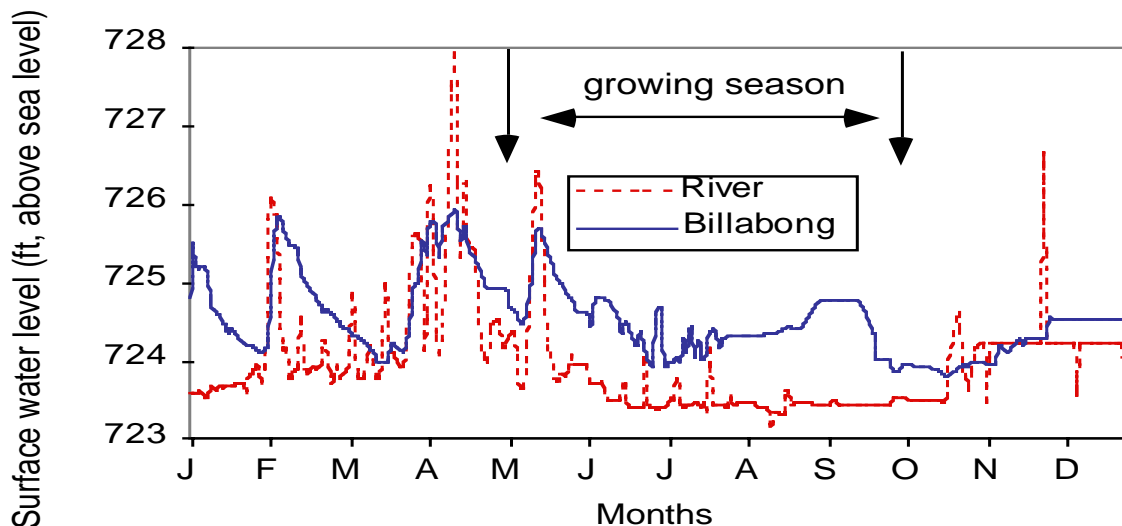


Figure 2. Daily surface water level (ft above sea level) in 2002.

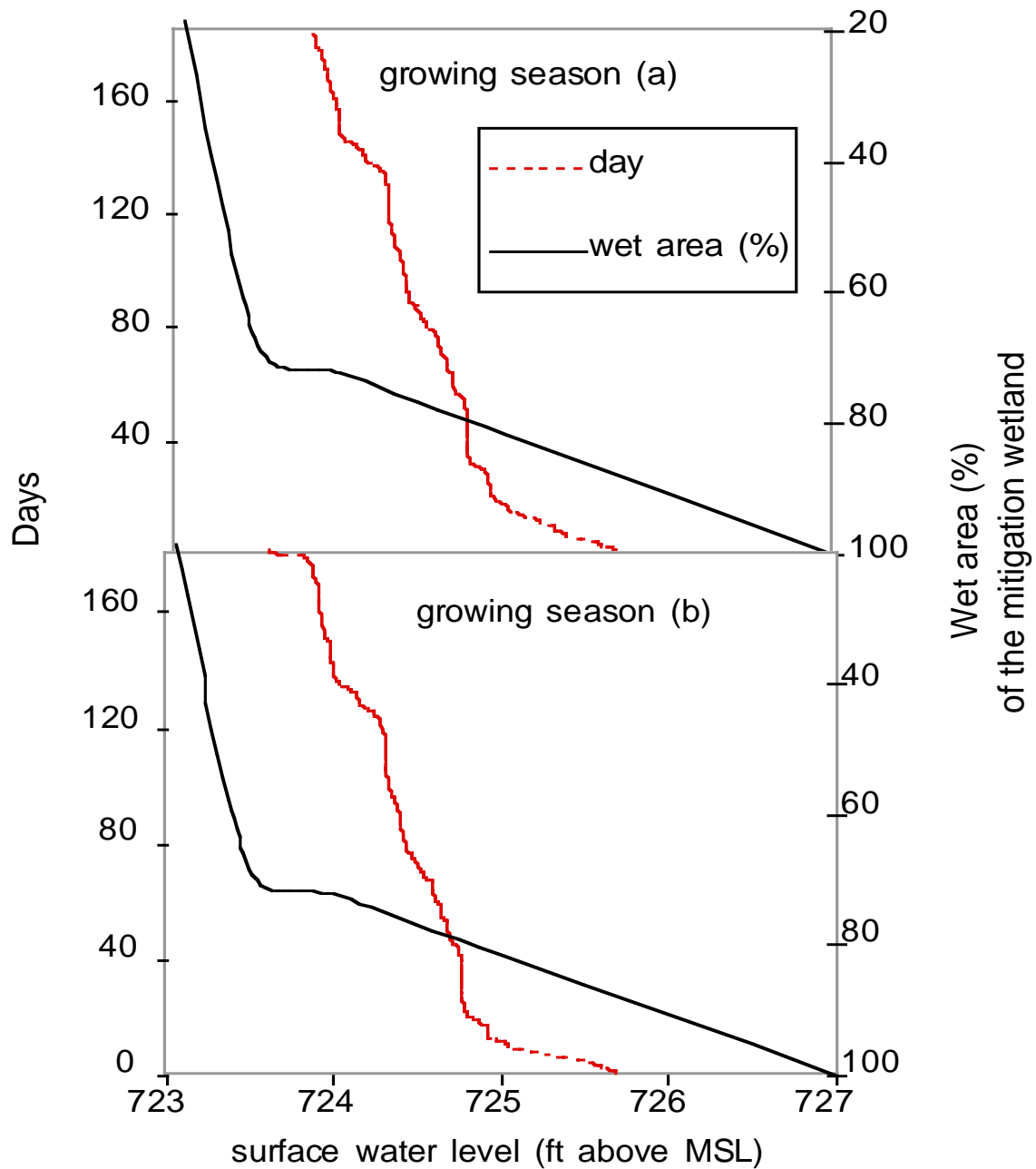


Figure 3. Relationship of surface water level to wet days and wet area (%) of the billabong during different definitions of the growing seasons (a: Apr 20 - Oct 19; b: May 1 - Oct 31), 2002.

Table 1. A summary of the wet days and wet area for the two growing seasons in 2002.

wet area%	68	72	82
growing seasons	wet days		
April 20 - October 19 2002	184	153	17
May 1 - October 31 2002	181	142	11

Table 2. Estimated annual hydrologic budgets, 2002.

hydrologic parameters	2002 (m/yr)
Surface inflow from river	7.0
Surface outflow	14.0
Precipitation	3.4
Evapotranspiration	2.2

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Appendix A. Estimated daily hydrologic budgets for the billabong at ORWRP, 2002.

Date	River Level (ft)	Bill. level (ft)	Volume (ft3)	Inflow (ft3)	Outflow (ft3)	Precipitation(ft3)	ET (ft3)
01/01/02	724.41	724.60	234311	0	0	0	0
01/02/02	723.58	724.20	234311	0	0	0	740
01/03/02	723.59	725.48	452885	0	0	0	508
01/04/02	723.56	725.30	404705	0	0	0	584
01/05/02	723.57	725.18	375542	0	0	0	1166
01/06/02	723.60	725.18	375542	0	0	0	1502
01/07/02	723.56	725.18	375542	0	0	0	1773
01/08/02	723.52	725.18	375542	0	0	0	5482
01/09/02	723.55	725.01	333273	0	0	0	3895
01/10/02	723.65	724.76	272390	0	0	0	455
01/11/02	723.65	724.66	247350	0	0	0	2265
01/12/02	723.62	724.63	240842	0	0	0	2661
01/13/02	723.64	724.59	231376	0	0	0	5617
01/14/02	723.67	724.54	219655	0	0	0	5349
01/15/02	723.65	724.48	205076	0	0	2022	5530
01/16/02	723.67	724.43	194669	0	0	674	1821
01/17/02	723.67	724.34	173918	0	0	0	2265
01/18/02	723.67	724.40	188634	0	0	0	6023
01/19/02	723.66	724.36	177723	0	0	0	5646
01/20/02	723.70	724.32	170093	0	0	1348	3471
01/21/02	723.69	724.28	160873	0	0	0	5045
01/22/02	723.69	724.23	148648	0	0	0	5312
01/23/02	723.69	724.21	144916	0	0	0	903
01/24/02	723.59	724.20	141360	0	0	0	1837
01/25/02	723.79	724.20	141805	0	0	674	283
01/26/02	723.81	724.19	139403	0	0	0	2187
01/27/02	723.87	724.16	132732	0	0	0	1830
01/28/02	723.93	724.13	126050	0	0	0	470
01/29/02	723.83	724.10	120443	0	0	0	3900
01/30/02	723.70	724.09	117209	0	0	33692	6435
01/31/02	723.89	724.12	125338	0	0	7412	4147

Date	River Level (ft)	Bill. level (ft)	Volume (ft3)	Inflow (ft3)	Outflow (ft3)	Precipitation(ft3)	ET (ft3)
02/01/02	724.21	724.17	134537	18088	0	0	1465
02/02/02	726.06	724.55	223369	374766	99405	45147	10143
02/03/02	726.05	725.14	364276	329473	401885	0	6372
02/04/02	725.87	725.63	491048	170213	738946	0	1263
02/05/02	725.73	725.81	538161	0	0	0	2385
02/06/02	724.80	725.83	544352	0	0	0	11197
02/07/02	724.14	725.76	524431	0	0	0	15110
02/08/02	724.16	725.61	487320	0	0	0	11948
02/09/02	724.00	725.53	465134	0	0	0	13284
02/10/02	723.77	725.47	449280	0	0	0	9616
02/11/02	723.84	725.45	445469	0	0	5391	1800
02/12/02	723.88	725.44	442192	0	0	0	2267
02/13/02	723.92	725.39	429349	0	0	0	8118
02/14/02	724.53	725.14	365839	0	0	0	13470
02/15/02	724.20	725.05	342628	0	0	0	13102
02/16/02	723.89	725.01	332107	0	0	0	2454
02/17/02	723.83	724.95	318481	0	0	0	1678
02/18/02	723.88	724.88	302340	0	0	0	908
02/19/02	723.90	724.84	292277	0	0	0	2130
02/20/02	723.88	724.80	282738	0	0	0	3815
02/21/02	723.89	724.73	265629	0	0	20889	5936
02/22/02	723.93	724.70	257894	0	0	0	10489
02/23/02	724.24	724.62	238984	0	0	0	2275
02/24/02	724.13	724.65	247042	0	0	0	4726
02/25/02	723.90	724.62	237990	0	0	0	15012
02/26/02	723.71	724.59	231564	0	0	0	10947
02/27/02	723.76	724.58	229611	0	0	2695	12410
02/28/02	723.93	724.49	209467	0	0	0	8949
03/01/02	723.77	724.49	209207	0	0	0	8100
03/02/02	723.79	724.43	194539	0	0	0	8387
03/03/02	723.83	724.40	187070	0	0	10108	3541
03/04/02	723.87	724.39	186205	0	0	0	4161
03/05/02	724.07	724.38	182298	0	0	0	7217
03/06/02	724.84	724.31	166802	150781	18316	0	10202
03/07/02	724.41	724.30	164787	42146	16217	1348	9464
03/08/02	723.83	724.30	163922	0	0	0	2626
03/09/02	723.76	724.28	160741	0	0	0	2840
03/10/02	723.77	724.26	154674	0	0	30323	7957
03/11/02	723.79	724.22	147141	0	0	0	9950
03/12/02	724.00	724.18	137471	0	0	0	9020
03/13/02	724.19	724.14	128077	20025	0	0	9891
03/14/02	724.00	724.12	123855	0	0	0	11859
03/15/02	723.81	724.06	111039	0	0	0	11860
03/16/02	723.77	723.97	91860	0	0	30997	12039
03/17/02	723.85	723.97	92005	0	0	0	2516
03/18/02	724.02	723.98	93147	11278	0	674	3920
03/19/02	724.96	723.98	93278	175908	0	0	7262
03/20/02	724.49	723.99	94992	88482	0	0	2415
03/21/02	724.15	724.17	135664	0	0	9434	3025
03/22/02	724.10	724.20	142007	0	0	0	7672
03/23/02	724.04	724.18	137395	0	0	0	10124
03/24/02	723.96	724.15	130706	0	0	0	12375
03/25/02	723.90	724.12	124333	0	0	0	7947
03/26/02	723.95	724.12	123953	0	0	11455	16651
03/27/02	724.16	724.22	146063	0	0	62667	14588
03/28/02	724.70	724.35	175558	107485	28245	1348	9065
03/29/02	725.24	724.58	228507	228317	108359	0	9949
03/30/02	725.58	724.92	310513	265904	274760	29649	10834
03/31/02	725.61	724.98	325827	261319	309763	0	11719

Date	River Level (ft)	Bill. level (ft)	Volume (ft3)	Inflow (ft3)	Outflow (ft3)	Precipitation(ft3)	ET (ft3)
04/01/02	725.56	724.98	325827	247518	309763	674	2519
04/02/02	725.41	725.51	459531	0	0	0	3157
04/03/02	724.13	725.49	453427	0	0	0	2350
04/04/02	724.61	725.35	419467	0	0	8086	2355
04/05/02	726.22	725.75	523136	236081	830542	0	4907
04/06/02	726.21	725.75	523136	233761	830542	0	4451
04/07/02	725.27	725.76	525760	0	0	0	2502
04/08/02	724.31	725.62	489203	0	0	0	3079
04/09/02	724.06	725.31	408579	0	0	2022	1810
04/10/02	724.24	725.68	505054	0	0	5391	4850
04/11/02	724.94	725.73	517829	0	0	0	5019
04/12/02	725.78	725.78	530667	9011	852342	0	4866
04/13/02	726.61	725.83	543567	305946	889932	3369	3726
04/14/02	727.45	725.87	556529	432579	928009	14151	1683
04/15/02	728.26	725.92	569552	527206	966567	116575	2238
04/16/02	726.25	725.85	550118	218795	909140	0	2802
04/17/02	725.32	725.53	465758	0	0	0	4003
04/18/02	725.72	725.56	473864	133133	690800	0	2722
04/19/02	726.27	725.72	515615	255123	808883	0	1052
04/20/02	725.55	725.52	463652	54096	662513	6065	4108
04/21/02	725.43	725.37	424835	72620	557347	1348	2871
04/22/02	725.43	725.34	415275	93826	532063	31671	3013
04/23/02	725.36	725.29	404455	73555	503766	0	4258
04/24/02	724.86	725.22	386338	0	0	0	4205
04/25/02	724.19	725.13	362630	0	0	0	3038
04/26/02	724.09	725.03	337921	0	0	674	1430
04/27/02	724.00	724.96	319737	0	0	0	4984
04/28/02	723.97	724.90	306615	0	0	35714	4738
04/29/02	724.43	724.90	306320	0	0	55929	4146
04/30/02	724.49	724.90	306686	0	0	0	3553
05/01/02	724.50	724.91	307713	0	0	0	809
05/02/02	724.51	724.91	308789	0	0	103098	4043
05/03/02	724.38	724.91	309662	0	0	28301	3234
05/04/02	724.15	724.92	310332	0	0	0	809
05/05/02	724.21	724.92	310798	0	0	0	0
05/06/02	724.30	724.68	254205	0	0	0	0
05/07/02	724.36	724.64	244774	0	0	20889	1617
05/08/02	724.37	724.64	243763	0	0	50538	809
05/09/02	724.05	724.61	235883	0	0	24258	1617
05/10/02	723.69	724.53	217094	0	0	5391	0
05/11/02	723.63	724.48	205228	0	0	674	1617
05/12/02	723.64	724.51	212237	0	0	0	4043
05/13/02	724.19	724.69	255183	0	0	129378	38005
05/14/02	724.82	724.88	301563	0	0	80861	0
05/15/02	725.36	725.03	339388	170440	341594	0	0
05/16/02	726.28	725.56	473338	292584	689337	0	3234
05/17/02	726.41	725.65	497813	299298	758078	5391	8895
05/18/02	726.26	725.68	504903	261672	778234	54581	0
05/19/02	725.58	725.59	481506	0	0	0	0
05/20/02	724.81	725.48	452721	0	0	0	0
05/21/02	724.17	725.38	425542	0	0	0	809
05/22/02	724.09	725.29	404590	0	0	0	0
05/23/02	723.95	725.21	384224	0	0	0	61454
05/24/02	723.77	725.11	357275	0	0	0	0
05/25/02	723.72	725.02	336543	0	0	16846	1617
05/26/02	723.81	724.99	329074	0	0	31671	6469
05/27/02	723.81	724.93	313261	0	0	0	1617
05/28/02	723.80	724.86	297238	0	0	0	7278
05/29/02	723.87	724.82	286554	0	0	68732	1617

Date	River Level (ft)	Bill. level (ft)	Volume (ft3)	Inflow (ft3)	Outflow (ft3)	Precipitation(ft3)	ET (ft3)
05/30/02	724.06	724.79	278703	0	0	16846	3234
05/31/02	723.95	724.75	270473	0	0	0	13746
06/01/02	723.94	724.63	241911	0	0	51212	0
06/02/02	723.95	724.61	237397	0	0	58624	1617
06/03/02	723.95	724.61	235879	0	0	2022	0
06/04/02	723.95	724.60	234362	0	0	2022	4852
06/05/02	723.95	724.59	232846	0	0	27628	3234
06/06/02	723.71	724.57	228021	0	0	66037	4043
06/07/02	723.69	724.42	192509	0	0	103772	3234
06/08/02	723.71	724.69	256367	0	0	0	6469
06/09/02	723.71	724.80	280821	0	0	0	4852
06/10/02	723.71	724.79	279349	0	0	0	5660
06/11/02	723.71	724.78	277879	0	0	0	5660
06/12/02	723.65	724.78	276752	0	0	0	5660
06/13/02	723.51	724.77	273906	0	0	2022	8086
06/14/02	723.49	724.75	268999	0	0	119944	0
06/15/02	723.49	724.70	256837	0	0	15498	809
06/16/02	723.49	724.64	244744	0	0	3369	2426
06/17/02	723.49	724.59	232721	0	0	0	809
06/18/02	723.49	724.42	192999	0	0	0	3234
06/19/02	723.63	724.34	173048	0	0	0	3234
06/20/02	723.71	724.49	208266	0	0	0	6469
06/21/02	723.45	724.46	202496	0	0	0	12129
06/22/02	723.41	724.37	181289	0	0	0	16981
06/23/02	723.41	724.28	161353	0	0	0	0
06/24/02	723.41	724.23	149340	0	0	0	0
06/25/02	723.41	724.18	138436	0	0	0	809
06/26/02	723.41	724.37	180837	0	0	0	1617
06/27/02	723.41	724.23	148085	0	0	87600	1617
06/28/02	724.03	724.14	128112	0	0	22911	0
06/29/02	723.43	723.99	96126	0	0	0	0
06/30/02	723.40	723.95	86923	0	0	0	1617
07/01/02	723.41	723.93	81493	0	0	0	13353
07/02/02	723.39	724.52	215536	0	0	0	18101
07/03/02	723.36	724.68	253284	0	0	0	18160
07/04/02	723.41	724.68	252724	0	0	0	17229
07/05/02	723.41	724.14	128597	0	0	0	27722
07/06/02	723.41	723.94	83452	0	0	0	15351
07/07/02	723.44	723.98	93278	0	0	0	10526
07/08/02	723.52	723.98	93278	0	0	0	21472
07/09/02	723.50	723.97	91906	0	0	0	23882
07/10/02	723.77	724.04	106298	0	0	60646	20487
07/11/02	723.69	723.99	94869	0	0	0	19836
07/12/02	723.44	724.00	98415	0	0	0	19389
07/13/02	723.41	724.28	159611	0	0	0	16688
07/14/02	723.42	724.09	116487	0	0	0	7229
07/15/02	723.43	724.31	167912	0	0	0	19703
07/16/02	723.43	724.41	189409	0	0	0	37340
07/17/02	723.45	724.03	103874	0	0	0	33795
07/18/02	723.45	724.15	131724	0	0	0	26875
07/19/02	723.43	724.24	150047	0	0	1348	26109
07/20/02	723.41	724.00	98673	0	0	2022	19418
07/21/02	723.45	724.00	97667	0	0	0	17661
07/22/02	723.33	724.15	130927	0	0	0	18559
07/23/02	724.16	724.36	178500	0	0	0	13146
07/24/02	723.45	724.37	180823	0	0	12129	23169
07/25/02	723.43	724.39	186217	0	0	6065	15560
07/26/02	723.43	724.26	156503	0	0	0	14148
07/27/02	723.43	724.16	133687	0	0	2022	15928
07/28/02	723.43	724.28	160757	0	0	90969	14678

Date	River Level (ft)	Bill. level (ft)	Volume (ft3)	Inflow (ft3)	Outflow (ft3)	Precipitation(ft3)	ET (ft3)
07/29/02	723.42	724.28	160757	0	0	0	14345
07/30/02	723.41	724.29	163472	0	0	6738	14012
07/31/02	723.53	724.30	164787	0	0	0	13679
08/01/02	723.46	724.30	164787	0	0	0	9505
08/02/02	723.43	724.30	164787	0	0	0	8482
08/03/02	723.45	724.30	164787	0	0	0	6351
08/04/02	723.45	724.30	164787	0	0	0	4168
08/05/02	723.45	724.30	164787	0	0	0	4428
08/06/02	723.45	724.30	164787	0	0	63341	11065
08/07/02	723.45	724.30	164787	0	0	0	10625
08/08/02	723.46	724.30	164787	0	0	0	6703
08/09/02	723.46	724.30	164787	0	0	0	6640
08/10/02	723.43	724.30	164787	0	0	0	11849
08/11/02	723.39	724.30	164787	0	0	0	11212
08/12/02	723.39	724.31	167202	0	0	0	17549
08/13/02	723.38	724.32	168996	0	0	0	12066
08/14/02	723.38	724.32	170167	0	0	0	16095
08/15/02	723.37	724.33	170713	0	0	68732	9074
08/16/02	723.16	724.33	170773	0	0	0	14087
08/17/02	723.32	724.33	171307	0	0	0	21065
08/18/02	723.32	724.34	174800	0	0	1348	30991
08/19/02	723.31	724.36	178362	0	0	4043	20562
08/20/02	723.31	724.38	181994	0	0	10781	18039
08/21/02	723.32	724.39	185695	0	0	0	15198
08/22/02	723.60	724.41	189327	0	0	0	7281
08/23/02	723.54	724.42	191917	0	0	0	6544
08/24/02	723.43	724.40	188510	0	0	7412	5935
08/25/02	723.45	724.39	185109	0	0	0	6067
08/26/02	723.45	724.39	184539	0	0	0	8069
08/27/02	723.45	724.40	187202	0	0	0	8253
08/28/02	723.45	724.42	193112	0	0	0	7451
08/29/02	723.45	724.46	202297	0	0	0	7358
08/30/02	723.45	724.52	214803	0	0	0	7264
08/31/02	723.45	724.58	230689	0	0	0	7171
09/01/02	723.43	724.64	244825	0	0	0	3234
09/02/02	723.42	724.69	256294	0	0	0	10512
09/03/02	723.42	724.73	265053	0	0	0	1617
09/04/02	723.42	724.75	271066	0	0	0	3234
09/05/02	723.42	724.77	274311	0	0	0	8895
09/06/02	723.42	724.77	274775	0	0	0	20215
09/07/02	723.42	724.77	274775	0	0	0	809
09/08/02	723.42	724.77	274775	0	0	674	0
09/09/02	723.49	724.77	274775	0	0	0	1617
09/10/02	723.49	724.77	274775	0	0	0	0
09/11/02	723.42	724.77	274775	0	0	0	35579
09/12/02	723.42	724.77	274775	0	0	0	0
09/13/02	723.42	724.77	274775	0	0	0	0
09/14/02	723.42	724.77	274775	0	0	0	12129
09/15/02	723.42	724.77	274775	0	0	0	5660
09/16/02	723.42	724.77	274775	0	0	170482	5660
09/17/02	723.42	724.77	274775	0	0	0	2426
09/18/02	723.42	724.77	274081	0	0	0	5660
09/19/02	723.42	724.75	269225	0	0	86926	25876
09/20/02	723.42	724.71	260236	0	0	50538	4852
09/21/02	723.42	724.65	247166	0	0	20889	4043
09/22/02	723.42	724.58	230091	0	0	0	26684
09/23/02	723.42	724.49	209113	0	0	0	2426
09/24/02	723.42	724.39	185019	0	0	0	1617
09/25/02	723.42	724.30	164624	0	0	0	5660

Date	River Level (ft)	Bill. level (ft)	Volume (ft3)	Inflow (ft3)	Outflow (ft3)	Precipitation(ft3)	ET (ft3)
09/26/02	723.42	724.01	99943	0	0	0	809
09/27/02	723.42	724.00	98714	0	0	45821	7278
09/28/02	723.42	724.00	97485	0	0	239214	0
09/29/02	723.42	723.99	96257	0	0	0	0
09/30/02	723.42	723.99	95030	0	0	0	0
10/01/02	723.42	723.98	93804	0	0	0	1617
10/02/02	723.50	723.86	67167	0	0	0	809
10/03/02	723.50	723.86	67167	0	0	0	0
10/04/02	723.50	723.86	67167	0	0	20215	809
10/05/02	723.50	723.86	67167	0	0	66710	0
10/06/02	723.50	723.95	87685	0	0	0	1617
10/07/02	723.50	723.95	86464	0	0	0	50134
10/08/02	723.50	723.94	85244	0	0	0	57411
10/09/02	723.50	723.94	84024	0	0	0	0
10/10/02	723.50	723.93	82806	0	0	0	6469
10/11/02	723.50	723.93	81588	0	0	0	35579
10/12/02	723.50	723.92	80371	0	0	26280	1617
10/13/02	723.50	723.92	79155	0	0	0	0
10/14/02	723.49	723.91	77939	0	0	0	52560
10/15/02	723.49	723.90	76725	0	0	0	5660
10/16/02	723.49	723.90	75511	0	0	5391	2426
10/17/02	723.49	723.89	74298	0	0	0	809
10/18/02	723.49	723.89	73086	0	0	0	0
10/19/02	723.49	723.88	71798	0	0	0	1617
10/20/02	723.48	723.86	67515	0	0	20215	28301
10/21/02	723.47	723.83	61717	0	0	0	1617
10/22/02	723.46	723.81	56058	0	0	0	0
10/23/02	723.50	723.80	54256	0	0	0	0
10/24/02	724.00	723.80	55084	24910	0	0	0
10/25/02	724.14	723.83	59642	39513	0	0	0
10/26/02	724.32	723.85	64627	62107	0	186654	1617
10/27/02	724.49	723.87	69628	89047	0	0	809
10/28/02	724.62	723.89	74479	111170	0	0	809
10/29/02	723.90	723.90	75828	0	0	0	2426
10/30/02	723.81	723.95	87297	0	0	30323	1617
10/31/02	723.77	723.92	79318	0	0	0	12938
11/01/02	723.61	723.94	84532	0	0	0	0
11/02/02	723.84	723.98	93278	0	0	0	809
11/03/02	724.13	723.98	93278	29959	0	0	0
11/04/02	724.17	723.98	93278	35539	0	0	0
11/05/02	724.20	723.98	93278	41167	0	0	0
11/06/02	724.21	723.97	90740	43912	0	51212	1617
11/07/02	724.21	723.96	89646	44364	0	0	0
11/08/02	723.46	723.96	88552	0	0	0	1617
11/09/02	724.21	723.95	87460	45255	0	0	2426
11/10/02	724.21	723.95	86779	45529	0	0	0
11/11/02	724.21	723.95	86714	45555	0	233824	0
11/12/02	724.21	724.14	128050	24117	0	0	0
11/13/02	724.21	724.18	137106	16087	0	0	0
11/14/02	724.21	724.16	132279	20752	0	0	14555
11/15/02	724.21	724.11	122811	27732	0	0	1617
11/16/02	724.21	724.10	120003	29491	0	22237	4043
11/17/02	724.21	724.13	126686	25107	0	0	0
11/18/02	724.21	724.17	136207	17053	0	0	3234
11/19/02	724.21	724.22	145684	0	0	0	0
11/20/02	724.21	724.24	151218	0	0	8086	0
11/21/02	724.21	724.26	155285	0	0	0	0
11/22/02	724.21	724.18	137199	15984	0	1348	1617
11/23/02	724.21	724.26	155680	0	0	6738	727
11/24/02	724.21	724.29	162511	0	0	0	0

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Date	River Level (ft)	Bill. level (ft)	Volume (ft3)	Inflow (ft3)	Outflow (ft3)	Precipitation(ft3)	ET (ft3)
11/25/02	724.21	724.29	162511	0	0	0	0
11/26/02	724.21	724.29	162511	0	0	0	0
11/27/02	724.21	724.29	162511	0	0	0	0
11/28/02	724.21	724.29	162511	0	0	674	3234
11/29/02	724.21	724.29	162511	0	0	0	809
11/30/02	726.66	724.29	162511	460107	13940	0	3234
12/01/02	724.21	724.29	163573	0	0	0	0
12/02/02	724.21	724.53	217874	0	0	0	0
12/03/02	724.21	724.53	217874	0	0	0	0
12/04/02	724.21	724.53	217874	0	0	0	0
12/05/02	724.21	724.53	217874	0	0	0	0
12/06/02	724.21	724.53	217874	0	0	1348	0
12/07/02	724.21	724.53	217874	0	0	0	0
12/08/02	724.21	724.53	217874	0	0	0	0
12/09/02	724.21	724.53	217874	0	0	0	1617
12/10/02	724.21	724.53	217874	0	0	0	0
12/11/02	724.21	724.53	217874	0	0	0	0
12/12/02	724.21	724.53	217874	0	0	17520	0
12/13/02	723.55	724.53	217874	0	0	16172	0
12/14/02	724.21	724.53	217874	0	0	48517	0
12/15/02	724.21	724.53	217874	0	0	4717	0
12/16/02	724.21	724.53	217874	0	0	0	0
12/17/02	724.21	724.53	217874	0	0	0	0
12/18/02	724.21	724.53	217874	0	0	0	0
12/19/02	724.21	724.53	217874	0	0	2695	0
12/20/02	724.21	724.53	217874	0	0	64015	0
12/21/02	724.21	724.53	217874	0	0	0	0
12/22/02	724.21	724.53	217874	0	0	0	6469
12/23/02	724.21	724.53	217874	0	0	0	2426
12/24/02	724.21	724.53	217874	0	0	0	1617
12/25/02	724.21	724.53	217874	0	0	0	2426
12/26/02	724.21	724.53	217874	0	0	674	0
12/27/02	724.21	724.53	217874	0	0	0	0
12/28/02	724.21	724.53	217874	0	0	0	0
12/29/02	724.21	724.53	217874	0	0	674	1617
12/30/02	724.21	724.53	217874	0	0	0	1617
12/31/02	724.00	724.53	217874	0	0	25606	0